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Virtual Manufacturing
- Forming Simulation -

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Sandia Nat'l Labs
Hal Morgan
Gerald Wellman

Virtual Manufacturing - Forming Simulation

Annual Meeting   9/14/95

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Sheet Metal Forming
The Challenge

- **Common Forming Defects**
  - Wrinkling
  - Tearing
  - Excessive Thinning
  - Springback
- **Current Sheet Metal Forming Practices are Costly**
  - 1 to 2 billion/year in die design and construction by the US automotive industry
  - Hundreds of millions per year spent on trial & error
  - Typical time to develop dies is 12 to 18 months
  - Comparrison with 2D disk forging
    - » 6 months for die design - empirical
    - » 1 week for die design - analytical

Virtual Manufacturing - Forming Simulation

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Sheet Metal Forming Simulation
The Benefits & The Issues

- **Computer Simulation Has Enormous Potential**

  – Reduce empirical trial & error

  – Lower development costs

  – Improve quality while reducing scrap

  – Reduce time to market

- **Current 3-D Simulation Limitations**

  – Computational efficiency

  – Model generation (CAD to finite element model)

  – Material models

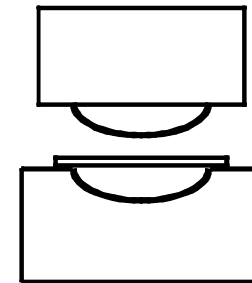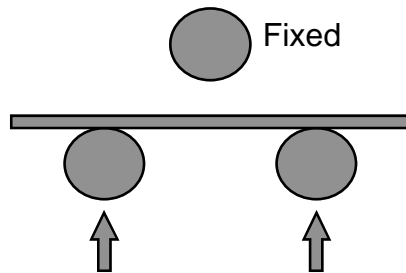 – Ability to represent physical phenomena

VM Forming Activities
Evaluation of FEA Codes (2D)

- **Focused on Prediction of Springback**

- **Two Applications Investigated (3 Point Bending & Stamping)**

Fixed

- **Six FEA Codes (both commercial & government developed) Exercised in a Blind Benchmark**
    - ABAQUS Explicit & Standard   - MSC/DYTRAN
    - DYNA3D/NIKE3D   - NIKE3D
    - JAS3D   - PAM STAMP

- **Solutions Compared with Experimental Data and Computational Results from EPDAN, INDEED, and MARC**
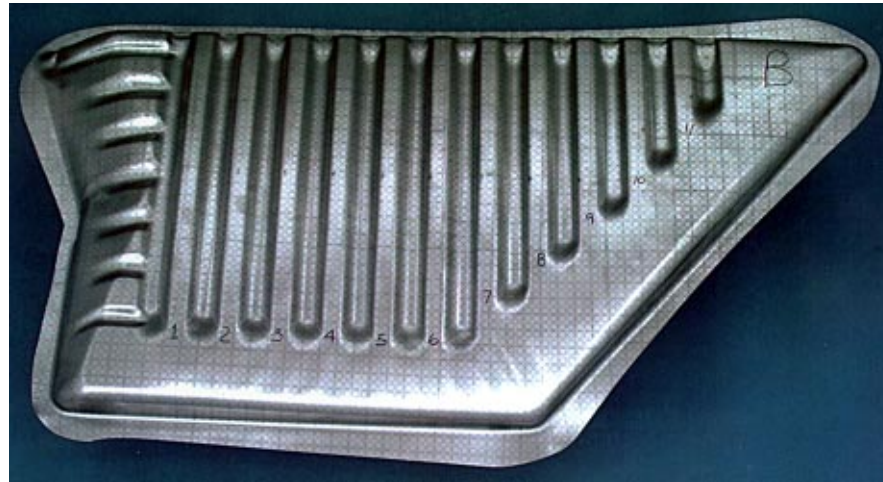
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VM Forming Activities
Evaluation of FEA Codes (3D)

- **Identified Industry Demonstration Part**

- **FEA Codes Being Applied**
  - ABAQUS Coupled
  - MSC/DYTRAN
  - NIKE3D

- **Other Codes Being Utilized**
  - Unigraphics
  - I-DEAS
  - Pro/Engineer
  - MSC/PATRAN

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VM Forming Activities
Status

- **Progress to Date**
  - CAD data provided to participants via Ludwig
  - FEA models built
  - Analysis underway

- **Lessons Learned**
  - CAD to FEA is major issue
  - Culture change required
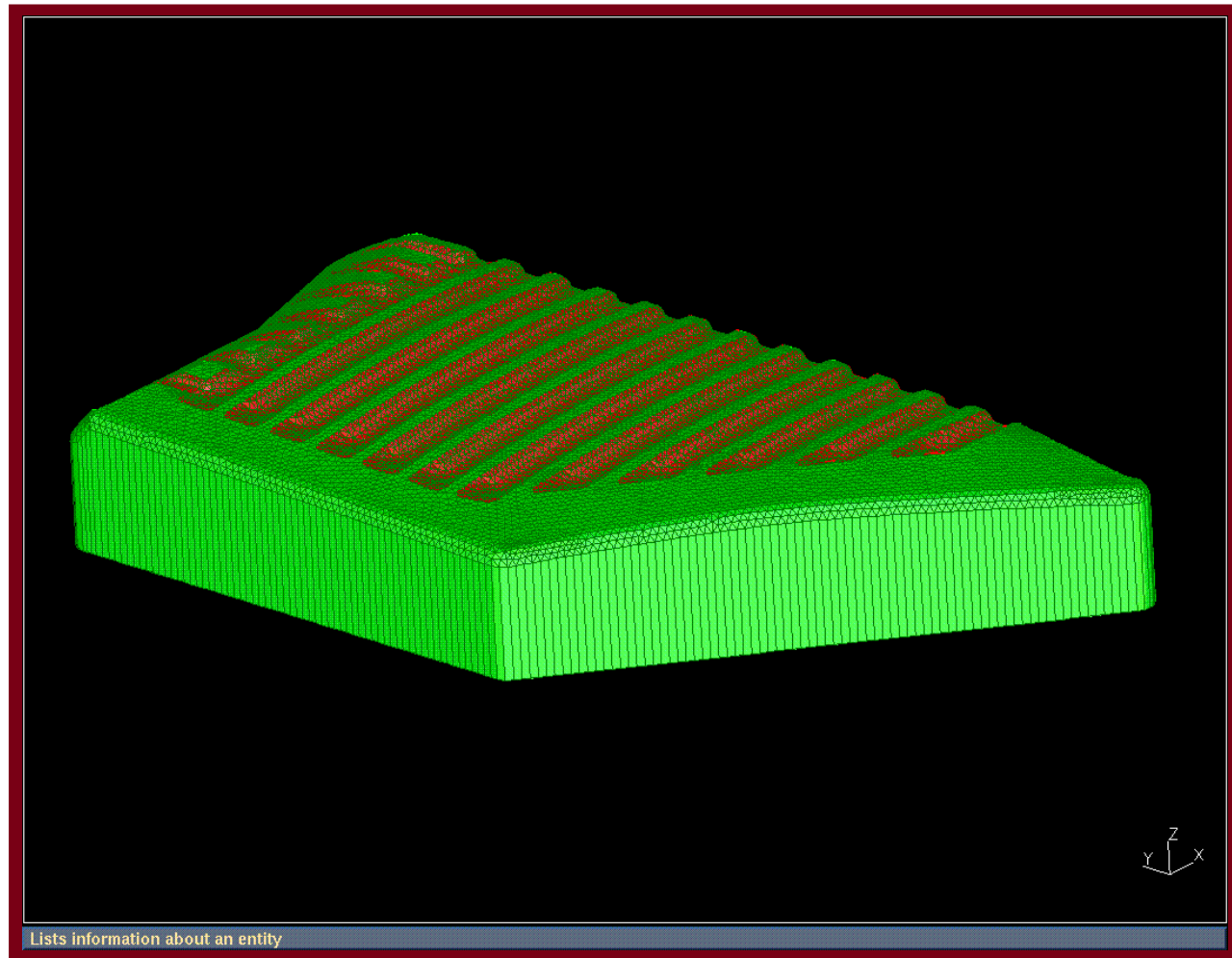 - File encryption/decryption

Virtual Manufacturing - Forming Simulation

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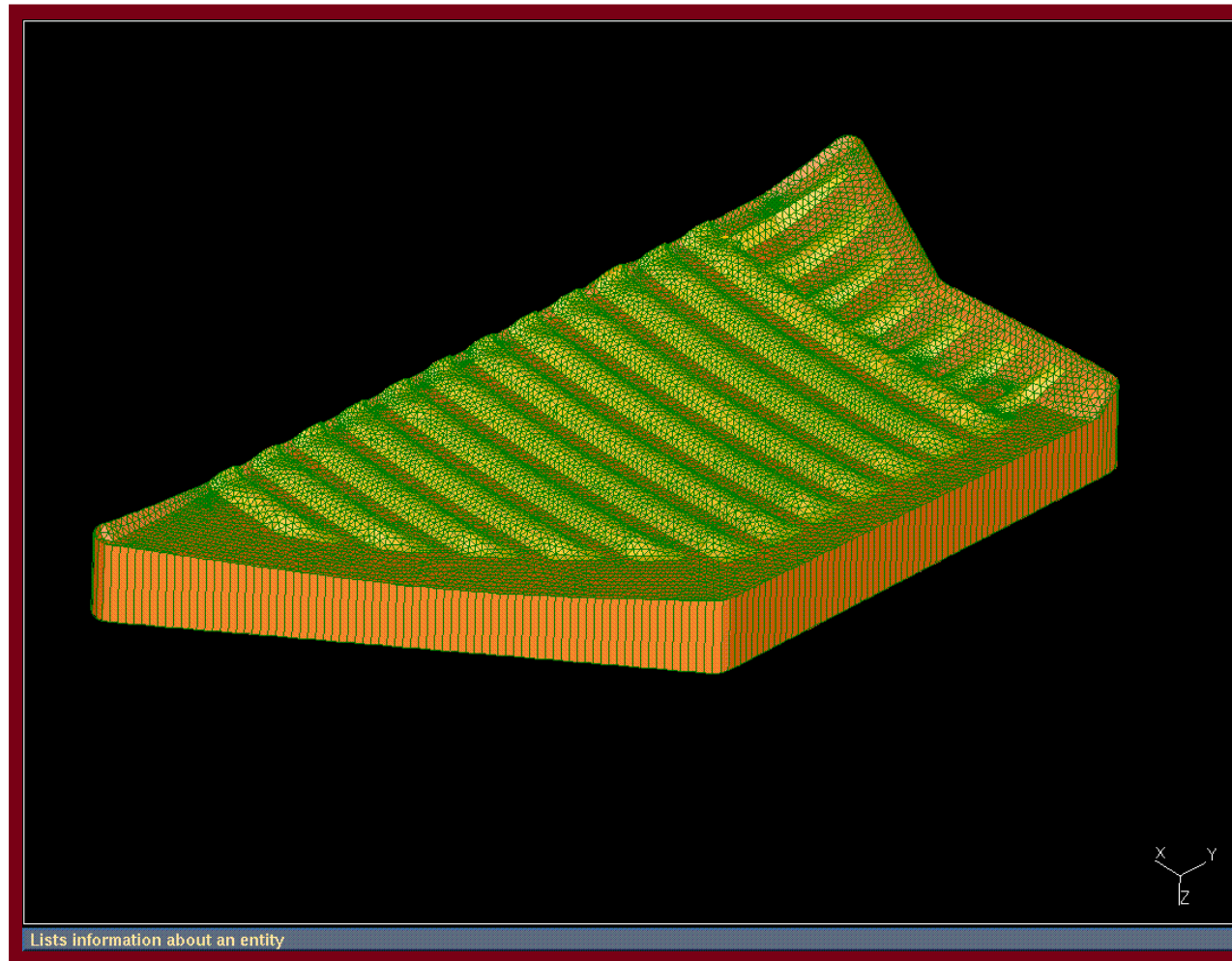
Forming Panel Mesh - Die Set/Stationary Side

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Forming Panel Mesh - Die Set/Moving Side

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Conclusions

- **Accurate Material Models are Critical & Essential**
- **CAD to FEA is a Major Issue**
- **File Encryption/Decryption Represents Problems**
- **Measured Current State-of-the-Art in Sheet Metal Forming Analysis Software**
- **Accurate Springback Prediction is Possible**
- **Sufficient Capability Demonstrated to Proceed**
- **Defining Requirements for ICLP Controller Activities is the Goal**

VM Forming Activities
Information Flow

- **Downstream Flow**

    - Forming information to ICLP

        » blank holder pressure

        » pressure vs. displacement

    - Cycle time & requirements information to Enterprise Modeling

- **Upstream Flow**

    - Die design information to PDEC

    - Design for Manufacturing

    - Cost information

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